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Personal
J. M. Petrie

(TTS-53)

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OPERATING INSTRUCTIONS

KS 19353 L1
OSCILLATOR

R. L. ARTMAN

NORTHEAST ELECTRONICS CORPORATION
AIRPORT ROAD
P. O. BOX 425 CONCORD, N. H. AREA CODE 603 224-7466

ADDENDUM AND ERRATA NOTES
KS 19353 L1 OSCILLATOR

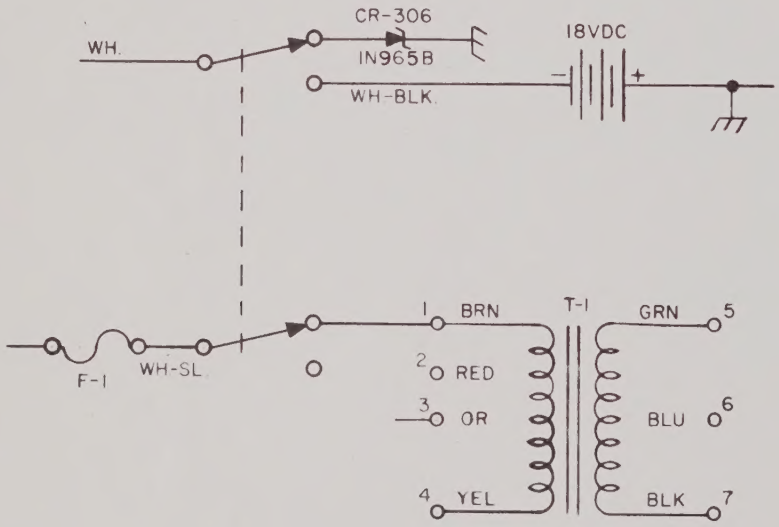
The following changes should be added to the instruction manual as follows:

1. On Page 1 of "Table of Replaceable Parts", change C9 OSC circuit reference to C9 560 KC ADJ.

2. On Page 8 of "Table of Replaceable Parts", add:

   CR306 Zener Diode P, 1N965B

3. On Fig. 12, add CR306 as shown below:



4. On Fig. 10, L2 and L3 should be 180 μh.

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NORTHEAST ELECTRONICS CORPORATION
CONCORD, NEW HAMPSHIRE

MODEL KS19353 L1 OSCILLATOR

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Table of Replaceable Parts		

ISSUED JULY 1964

BAT TEST
65 70 75 80 90
FREQUENCY CPS
OUTPUT VERNIER
IN
OUT
FREQUENCY VERNIER
OUTPUT LEVEL
(—30 TO +10 DBM)
MODEL TTS-53 OSCILLATOR
NORTHEAST ELECTRONICS CORP.
CONCORD, N. H.
X1
X10
X100
X1000
FREQ RANGE
POWER
ON
OFF
135 5KC TO 560KC
900
50CPS TO 50KC
600
900 HOLD
600 HOLD
DIAL/BAT
FUNCTION
DIAL
310 309 T R
OUTPUT
S T R 310 309 241

BAT TEST
FREQUENCY CPS
OUTPUT VERNIER
IN
OUT
FREQUENCY VERNIER
OUTPUT LEVEL
-30 TO +10 DBM
KS-19353 LI OSCILLATOR
SERIAL NO.
MADE FOR
WESTERN ELECTRIC CO.
BY
NORTHEAST ELECTRONICS CORP.
X1
X10
X100
X1000
FREQ RANGE
POWER
ON
OFF
50 CPS TO 50 KC
900
600
900 HOLD
600 HOLD
135
5 KC TO 560 KC
DIAL/BAT
FUNCTION
DIAL
310
309
T
R
OUTPUT
S
T
R
310
309
241

Fig 1

KS19353 L1 OSCILLATOR

OPERATING INSTRUCTIONS

1.0 GENERAL

1.01 The variable frequency oscillator described herein covers the range from 50 cps to 560 KC in four decade steps. It delivers any power level in the range from +10 dbm to -30 dbm with balanced output impedances of 600 or 900 ohms from 50 cps to 50 KC and 135 ohms from 5 KC to 560 KC. The set is operated from either its own internal batteries or from an internal rectifier supply which operates from a 117-volt, 60 cps AC supply; both supplies can be checked by a self-contained meter. The set contains "dial-through provisions" and it has a switchable hold circuit and multiple output jacks and terminals.

1.02 The set measures approximately 8" x 11" x 8 1/2", including a detachable cover, and it weighs about 16 pounds after the batteries are installed.

1.03 A front panel view of the set is shown in Fig. 1.

2.0 PERFORMANCE AND SPECIFICATIONS

2.01 After switching the power to ON and allowing for internal stabilization, the set has the following performance.

2.02 Frequency Range

50 cps to 560 KC in four overlapping decade bands.

2.03 Frequency Vernier

Range: Maximum 5% of indicated reading depending on frequency setting.

2.04 Frequency Accuracy

±3% over range of temperature, battery voltage variation, and resetability, when the vernier control is in its detented position.

2.05 Frequency Stability

±0.1% for one hour provided temperature does not change more than ±5°F.

2.06 Output Level

-30 dbm to +10 dbm.

2.07 Output Level Control

4 position attenuator with approximately 10 db steps, and vernier control with overlapping range of approximately 12 db.

2.08 Distortion

Total harmonic output at least 40 db below that of the fundamental.

2.09 Output Impedance

50 cps to 100 cps - 600 and 900 ohms balanced, ±5%, ±10°
100 cps to 50 KC - 600 and 900 ohms balanced, ±5%, ±5°
5 KC to 560 KC - 135 ohms balanced, ±5%, ±5°

2.10 Line Holding

Switchable for 600 and 900 ohm impedances.
DC resistance - 700 ohms, ±10%.

2.11 Level Stability

a. Between any two frequencies within the range for the output impedance used, level will be within 0.4 db.

b. Level will stay within ±0.05 db for 1 hour, provided the battery voltage is above cut-off, and the temperature does not vary more than ±5°F.

2.12 Output Noise

65 db below signal output level at any frequency or below -90 dbm whichever is greater.

2.13 Balance

600 and 900 ohms; better than 70 db at 100 cps and 55 db at 3000 cps.

135 ohms; 50 db at 5 KC, 30 db at 560 KC.

2.14 Temperature Range

40°F to 120°F

2.15 Power Requirements

a. Battery operation, 12 flashlight D cells

Battery life - approximately 180 hours, intermittent operation

b. AC Operation - 117V, ±10%, 60 cps, approximately 5 watts

c. A meter is available for battery test or checking AC operation.

3.0 CONTROLS AND JACKS

Controls

3.01 POWER

A two-position toggle switch for turning the DC power ON or OFF for either AC or battery operation.

3.02 FREQUENCY CPS

A continuous tuning control whose dial is calibrated between 50 and 560. Counterclockwise rotation of the knob increases the frequency.

3.03 FREQUENCY VERNIER

A vernier frequency adjustment which permits a more precise setting of the frequency when desired. It has a detented position indicated as OUT. When the main dial is used to set the frequency, the FREQUENCY VERNIER must be placed in this OUT position. Approximately in the middle of the range of this control, a frequency will be produced which is equal to that obtained in the OUT position. The vernier frequency adjustment can thus vary the output frequency both above and below the frequency obtained in the OUT position. The range of this control is approximately ±2.5% at the high frequency end of the dial and approximately ±0.25% at the low frequency end of the dial.

3.04 FREQ RANGE

A four-position rotary switch which provides decade multiplying factors from 1 to 1000 for the frequencies shown on the frequency dial.

3.05 FUNCTION

A six-position rotary switch which has the following settings.

a. DIAL/BAT - Selects dial-through condition and tests batteries or output of AC power supply.

b. 600 HOLD - Selects 600 ohms output with holding circuit.

c. 900 HOLD - Selects 900 ohms output with holding circuit.

d. 600 - Selects 600 ohms output; no holding circuit.

e. 900 - Selects 900 ohms output; no holding circuit.

f. 135 - Selects 135 ohms output.

3.06 OUTPUT LEVEL

A four-position rotary switch which changes the output level by approximately 10 db per step. Maximum output is obtained in the extreme clockwise position.

3.07 OUTPUT VERNIER

A continuous level control with uncalibrated reference marks, which covers a range of approximately 12 db.

3.08 BAT - AC Switch

A slide switch located in the rear of the set. It is used to switch the set to either internal battery or external AC operation.

3.09 OUTPUT

The jacks and terminals under OUTPUT provide the output signals from the oscillator. All jacks and terminals are in parallel at all times, and the S binding post (chassis ground) is connected to the sleeves of the output jacks. The following are provided:

a. A pair of insulated binding posts mounted on 3/4" centers and designated T and R. These will mate with General Radio Company 274B plugs or equivalent.

b. An uninsulated binding post designated S. It is connected to the oscillator chassis ground.

c. A jack designated 310 which will accept the Western Electric Company 310 plug with output connections to the tip and ring.

d. A jack designated 309 which will accept the Western Electric Company 309 plug with output connections to the tip and ring.

e. A pair of jacks with 5/8" center spacing and designated 241. They will accept a Western Electric Company 241A plug with output connections to the tips.

3.10 DIAL

The jacks and terminals under DIAL are in parallel and connected tip to tip and ring to ring to the jacks and binding posts under OUTPUT, when the FUNCTION switch is in

the DIAL/BAT position. The following are provided:

a. A jack designated as 310 which will accept a Western Electric Company 310 plug.

b. A jack designated as 309 which will accept a Western Electric Company 309 plug.

c. A pair of insulated clip posts for attaching clips of the Western Electric Company 1011B handset or similar device. They are designated T and R.

3.11 117-Volt 60 CPS Power Receptacle

Located in the rear of the set. A power cord supplied with the set is plugged in this receptacle to supply AC power.

3.12 Fuses

Two fuses, Type 3AG-SLO-BLO 1/10, are located in the rear of the set; one is connected in the primary of the AC power supply and the other is a spare.

4.0 CIRCUIT DESCRIPTION

General

4.01 The set consists essentially of the following subsections.

Oscillator
Control Circuit
Output Amplifier
Power Section
Output Attenuators

Oscillator

4.02 The oscillating circuit or oscillating portion of this set is of the Wien bridge type. A greatly simplified schematic of this is shown in Fig. 2A. It will be seen that a differential output of the two halves of this bridge are amplified and reapplied back to the bridge. The left half of the bridge determines the frequency at which oscillations will occur. The right half of the bridge determines the overall gain.

4.03 In this set the resistance values of the frequency determining elements are equal and the frequency will be:

$$f_o = \frac{1}{2\pi R_o C_o}$$

The left half of the bridge with R_o and C_o has the characteristic of providing maximum transmission and 0^o phase shift at the frequency indicated above. The right half of the bridge, which consists of RT1 and R101, has a loss which is independent of frequency. The differential output of the bridge will be a function of the loss associated with the two halves of the bridge. If these losses were exactly equal for the frequency when 0^o phase shift occurs, there would be no output. Therefore, an oscillator must work somewhat off of this null by setting the loss of the right half of the bridge to be slightly different from the left half. This produces a small output which is then amplified and fed back into the bridge. Whenever overall loop gain from bridge output through the amplifier back to the bridge output is equal to unity with a 0^o phase shift, oscillations will be sustained. To maintain this unity gain, independent of frequency and transistor parameters, normally requires some sort of automatic gain control to regulate the loss through the right half of the bridge. In this set the value of RT1 is changed to regulate the loop gain to exactly unity. This is done by means of a control amplifier as shown in Fig. 2B.

4.04 The frequency of oscillation can be varied by changing either the value of C1 and C7 simultaneously, or by changing

the values of R1A and R1B. In this set, the resistors are changed by means of the main tuning knob. These resistors consist of a ganged dual non-linear potentiometer which provides an 11:1 change in resistance which consequently results in an 11:1 change in frequency.

4.05 Since normal potentiometers are capable of being adjusted from their maximum value to a value very close to zero, some means must be provided to limit the minimum value of resistance. This is done by adding resistances external to the potentiometers. This is shown in Fig. 2B where the added resistors are R2A and R2B. It will be noticed that the reactive half of the bridge has not been materially changed and it will still perform as indicated above. These added resistors can also be utilized as an initial calibration adjustment to offset part of the normal tolerance of the ganged potentiometers.

4.06 It was inferred that the frequency of oscillation is determined in part by the total magnitude of the resistance in parallel with C1. In the discussion, this had been assumed to be entirely due to R1A and R1B. Practically, there is also a resistive component associated with the amplifier input since this input impedance is finite. This will normally introduce a frequency error and, by unbalancing the resistance component of the bridge, it may cause other problems. One method of circumventing this is to add a resistive component across C1. This is also shown in Fig. 2B by the addition of R6. The value of this is normally set to be approximately equal to the input impedance of the amplifier and eliminates the frequency errors and other problems mentioned above.

4.07 It is desired to have an additional control of frequency covering a very small range. In this set, this is provided by the FREQUENCY VERNIER. This vernier control can be done in many ways, including mechanical methods. In this set, it is done by varying a small part of one of the resistors of the bridge. This is shown in Fig. 2B by the insertion of R5 and R5A. In the detented or OUT position of the vernier, R5 is shorted and R5A is inserted in the circuit. The value of R5 can now be adjusted around the value of R5A to produce a small frequency change. Since this resistance is in series with R1B, its effect will be a function of the value of R1B. At the high frequency end of the dial, the value of R1B is at its minimum so the effect of the vernier R5 will be at its maximum. The insertion of the frequency vernier does unbalance the values of the resistance, but as this unbalance is limited to a small percentage of the overall resistance, it does not produce any problems.

4.08 The circuits shown so far produce an 11:1 change in frequency. This 11:1 change is further changed in decade steps by changing the values of the capacitors in the left hand side of the bridge. This is done by the FREQUENCY RANGE switch and is shown added in Fig. 9, which adds C2, C3, and C4 and C8, C9, and C10.

4.09 Because of the presence of stray capacitance which, although small, becomes significant on the highest frequency range where the bridge capacitors themselves are small, it is necessary to offset these possible errors in much the same manner as the input impedance of the amplifier had to be offset. This is done by adding a capacitive component across part of the tuning resistor. This is also shown in Fig. 9 by the addition of C9. This adds a small frequency shift at the upper end of the highest band to offset the effects of the stray capacitance.

4.10 The amplifying portion of the oscillator consists of two stages of common emitter amplification, Q1 and Q2, followed by a Class B complementary-symmetry emitter-follower. The schematic of this, along with the bridge, is shown on Fig. 9. The action of all this can be best described by imagining a sine wave applied to the base of Q1. If this sine wave initially goes through a positive half cycle, the current in the base of Q1 will decrease which causes a decrease in the current in the collector circuit. This produces a decrease in the voltage drop across its collector resistor R103, which means that the voltage is going more toward battery negative, and a negative half cycle will appear at the collector. This negative half cycle is coupled, by C102, which is a DC blocking capacitor, to the base of Q2. Q2 is an NPN transistor. Its collector has to be positive with respect to its emitter for bias considerations. This is done by returning the emitter to a source of negative battery. The negative half cycle will decrease the base and collector current of Q2 which, by similar reasoning, produces a positive half cycle at its collector. This positive half cycle is applied to the base of both Q3 and Q4. A positive-going voltage applied to the base of Q3 will make it conduct, whereas a positive-going voltage at the base of Q4 will prevent conduction and Q4 will remain cutoff. Thus, Q3 will conduct and pass the positive half cycle. All of the above has been for a positive half cycle input. If this input were truly a sine wave, this input positive half cycle would be followed in time by a negative half cycle. Similar, but reverse reasoning, will show that this negative half cycle will produce a negative half cycle at the collector of Q2. This negative-going voltage will cut off Q3 since this is an NPN, but will cause Q4 to conduct since this is a PNP transistor. The conduction of Q4 will produce a negative half cycle at the output of the amplifier. Thus an input sine wave at the input will be reproduced as a sine wave at the output even though the output stages only conduct on half cycles. Such a circuit has more efficiency than a conventional Class A emitter-follower and thus saves some battery power. It will also be noticed that the output of the amplifier is in phase with the input.

4.11 Bias for Q1 and Q2 are derived from their collectors. This produces a stable bias for widely varying conditions such as temperature and normal transistor beta variations. That such is the case can be seen by examining the circuit of Q1. Suppose

for the moment, that the ambient temperature was increased. Two significant parameters change, the leakage and the beta, and both increase. In germanium transistors, leakage at high temperatures can be a problem. Notice, however as the leakage current increases, it will flow in the collector and produce a large voltage drop across the collector resistor R103. This means that the voltage to ground at this point will decrease and the voltage difference across R102 will also decrease. This means that less bias current will be applied to the base, which, in turn, means that less collector current wants to flow as a result of this bias current. The net result is that the total change in collector current due to the change of temperature is minimized.

4.12 Bias for the Class B output stages is derived from the voltage divider consisting of R110, R111, and R112. The values chosen for these result in some current flow in Q4 and Q3 when no signal is applied; this reduces the amount of time where neither transistor is conducting under the influence of a signal. If both transistors were cut-off when there is no signal, a so-called crossover type distortion results; a slight forward bias, as used here, can reduce or eliminate this distortion. Since, in addition, negative feedback is used, the harmonics resulting from the crossover distortion are virtually eliminated.

Control Circuit

4.13 It was pointed out earlier that the loop gain of the entire oscillator must be unity for stable oscillations to occur. To keep low distortion, this gain of unity must be achieved with signal levels at a point where overloading of the amplifier does not occur. It was also pointed out that this can be done by varying the loss of the resistive half of the Wien bridge. This is normally done by some thermally sensitive material which senses the level of oscillations and adjusts itself to a value determined by this level. Such a device also responds to ambient temperature so that the level of oscillation would change as the temperature changes. In this set a thermal sensitive device is used, but in a slightly different manner.

4.14 This sensitive device, shown as RT1 in Fig. 9, consists of two elements, a thermal bead (TH) surrounded by a heating element (HTR). The thermistor is made from a material in which the resistance decreases as its temperature is increased. If we ignore the heater for a moment and imagine that the oscillator level is rising due to high gain within the amplifier, a relatively large signal level will appear across the thermistor bead and some power is dissipated within the bead. This power dissipation is in the form of heat and thus the temperature of the bead will increase and lower its resistance. Lowering of this resistance increases the overall negative feedback, which lowers the loop gain of the entire set; this, in turn, tends to reduce the oscillator level. This is one form of automatic gain control.

4.15 The above control action is augmented by a second path which involves the circuit of Q5. This circuitry is also shown on Fig. 9. The signal appearing at the emitter of Q3 and Q4 is AC coupled through C107 and fed into two diodes, one a conventional one, CR102, the other a zener type, CR101. CR102 has its anode very close to battery voltage, and acts as a DC restorer by limiting the negative excursion of the output signal to a point roughly equal to the bias on its anode. The signal at the junction of these two diodes will vary from this point near battery to a more positive point determined by the peak-to-peak amplitude of the oscillations. When the peak-to-peak excursions are low, CR101 will not break down. At a sufficiently high oscillator level, it will break down and cause base current to flow in Q5. The collector current of Q5 is fed into the heater of RT1 and will heat the bead, lower its resistance, and lower the gain within the oscillator. Thus, the level of the oscillator will be limited to the point where the peak-to-peak excursion causes CR101 to break down. Any tendency to rise to a value higher than this will be corrected by the increased current flow through Q5 and the heater of RT1. With no heater current, the gain is intentionally set to the point that the output amplitude will be larger than this critical voltage. This means that when the oscillator is first turned on, the output level will be very high, certainly high enough to cause the control amplifier to take over and produce heater current. This then will stabilize the oscillating level to a prescribed value and will hold it at this value for changes in gain due to temperature, battery voltage, and the like.

4.16 The amount of heater current flowing is not only a function of the oscillator level, but also, even if in a small fashion, to the voltage drops associated with CR101, CR102, and Q5. These voltage drops are all temperature sensitive and would produce a small change in output level with temperature if it were not corrected. This correction is applied by means of RT2 which is a thermistor which reacts only to the ambient temperature and not to signal levels.

Output Amplifier

4.17 For 135-ohm operation, the input of the amplifier is connected to the output of the oscillator through padding resistors R253, R253A and condenser C226, in series with a low-pass filter consisting of C223, C224, C225, L2 and L3. The low-pass filter response is flat up to 560 KC, and the 3 db point is at approximately 800 KC. This filter is primarily used to attenuate the harmonics of the oscillator frequency in the 400 to 560 KC region.

4.18 The output amplifier is of a configuration very similar to the amplifier used in the oscillator section. Two common emitter amplifiers are followed by a Class B complementary symmetry emitter follower output employing overall negative feedback from the output back to the first emitter as shown on Fig. 10. This

results in the extremely low output impedance (less than 1 ohm) of the amplifier. This output impedance will show up as one component of the impedance as seen from the line. Because external build-out resistors are used, the amplifier output impedance can change by a factor of 2:1 without changing the output impedance of the entire set by as much as one percent.

4.19 The primary function of this output amplifier is to provide adequate isolation between the oscillator proper and the line terminals. Secondary functions are to provide matching of the output transformers and attenuators without influencing the performance of the oscillating section.

Output Attenuators

4.20 The output of the power amplifier produces the required voltage at a very low impedance. This voltage is fed into a matching network and from there to the output transformers as shown in Fig. 11. It will be noticed that two transformers are used. One covers the frequency range of 50 cps to 50 KC for the 600 and 900 ohm positions. A second transformer is used to provide a 135-ohm impedance and covers the frequency range of 5 KC to 560 KC. When the set is operated at maximum output, approximately 9 ohms appear between the output amplifier and the primary of the 600 and 900 ohm transformer and 19 ohms between the output amplifier and the 135 ohm transformer. This 9-ohm or 19-ohm series resistance, along with the output impedance of the amplifier, will be transformed by the turns ratio of the transformer into an impedance which the line will see. Further resistance is added on the two sides of the output line circuit so that the indicated output impedance will be accurate and be balanced. When the output control is turned one step counterclockwise, approximately 10 db of loss is added at the amplifier input. This is done by inserting a pad consisting of R254 and R255 between the output of the oscillator and resistors R256 (OUTPUT VERNIER) and R257 as shown in Fig. 10. When the OUTPUT LEVEL control is turned to the second step counterclockwise, approximately 20 db is added in the transformer primary. This is done in an L-pad in such a manner as to preserve the impedance as seen by the primary of the transformer; as a result, there is little change in the impedance as seen looking into the OUTPUT jacks. This is shown on Fig. 11 as R227 and R228 for 135 ohms and R224 and R225 for 600 and 900 ohms. The 10 db of loss which was placed at the amplifier input is removed in this step.

4.21 When the OUTPUT LEVEL is at its maximum counterclockwise position, the 20 db loss in the primary of the transformer and the 10 db of loss at the amplifier input terminals are both inserted. This reduces the total output 30 db below its maximum. In this position the output level is approximately -20 dbm with

the continuous OUTPUT VERNIER control at its maximum and less than -30 dbm with the OUTPUT VERNIER control at its minimum. The continuous control is of a conventional design and appears at the amplifier input as R256 in Fig. 10. R257 is in series with R256 to restrict the range of the OUTPUT VERNIER to just over 10 db.

Power Section

4.22 When operating off its internal batteries, a maximum of 18 volts is available. The nominal cut-off for these batteries is 12.5 volts which corresponds to the bottom of the green arc of the battery test meter. Two voltages are indicated on the schematics. These are labeled as 18V and 11V. The 18V points correspond to the battery voltage. This voltage supplies the collectors of two series regulating transistors, namely, Q6 and Q11, the emitter of the second amplifier transistor, Q8, and the collector of one of the output transistors (Q10). Note that Q10 is supplied through a decoupling network consisting of R226, C221 and C222. The first 11V is derived from a series regulator (Q11) which is located in the amplifier board. (See Fig. 10.) This transistor is driven from a zener diode, CR301, which is incorporated in its base circuit; it produces a very stable voltage for a normal range of battery voltages. The output of this regulator transistor provides power for the first transistor in the power amplifier, Q7, and provides bias voltages for its push-pull output transistors. In addition, the first 11V source drives another series regulator transistor (Q6), located on the oscillator board. (See Fig. 9.) The oscillator section is run from the 11V derived from this second series regulating transistor.

4.23 Note that the value of the voltage marked "11V" on the terminal boards of the output amplifier and the oscillator is approximate only. Furthermore, it should be noted that the conductors marked 11V on the oscillator board are actually approximately 0.25V lower than the voltage appearing on the 11V terminal lug.

4.24 When the set is operated from external AC supply, a stepdown transformer drives a four-diode full-wave rectifier bridge to produce approximately 16 volts DC under load. This is filtered by a double RC filter to reduce ripple. Further reduction of ripple is accomplished by the two series regulators discussed above. The rectifier circuit is shown on Fig. 12.

4.25 The AC input to the power transformer is controlled by the BAT-AC switch located in the rear of the set. In the BAT position, no AC is applied to the transformer. In the AC position, full power is applied and the power supply is operating. This is independent of the position of the POWER switch.

4.26 The POWER switch controls the DC voltage to the circuitry. In the BAT position of the BAT-AC switch (on the rear panel), the POWER switch connects the circuits to the internal batteries when in the ON position, and disconnects the circuits when in the OFF position. In the AC position of the BAT-AC switch, the POWER switch connects the 18V points in the circuitry to the DC output of the rectifiers in the ON position. In the OFF position it disconnects the circuitry from the rectifier output and connects a resistive load to the DC output of the rectifiers. This resistor load (R303) duplicates the current demand of the circuitry and keeps the DC output of the supply at a nominal voltage. Note that the POWER switch does not turn off the AC input, either at the primary or secondary of the power transformer, T1.

4.27 With the POWER switch in the ON position and the FUNCTION switch in the DIAL/BAT position, the battery test meter is connected across the batteries when the BAT-AC switch is in the BAT position and across the DC output of the AC supply when the BAT-AC switch is in the AC position. For proper operation of the oscillator, the meter should read in the green area for either battery or AC operation.

5.0 OPERATING PROCEDURE

5.01 Initial Steps

Unlatch and open lid. The lid can be detached by sliding it to the right side of the instrument. An AC power cord is stored under the bracket in the lid; it is used only if AC operation is desired instead of internal battery.

5.02 Installation of Batteries

Sets are shipped without batteries. Twelve D type flashlight cells must be installed as follows:

1. Unfasten the four captive screws on the front panel which hold the panel to the case. They are identified by large slotted heads and are set in from the four smaller screws in each cover by approximately 1". Do NOT loosen the smaller screws.

2. Remove the set from the case. This can be conveniently done by setting the set on its knobs upside down. The case can then be lifted off.

3. Four cardboard cylindrical tubes are mounted in the battery brackets. Remove these tubes and insert three flashlight type D cells in each tube. Be sure that the top or positive pole of each battery comes in contact with the bottom or negative pole of the battery in front of it.

4. Insert the tube including the three batteries in one set of battery holders.

   CAUTION: The exposed top or positive pole of the battery group should be inserted in the red terminal on the battery holders. The exposed bottom or negative pole of the battery group should come in contact with the raised contact at the opposite end of the battery holder.

5. Three additional sets of tubes with batteries should be mounted in the remaining battery holders.

6. Replace the set within the case. Set the case on a flat surface in normal upright position. Holding the set by the sides of the front panel, slowly insert the set into the case, guiding the cut-outs past the basket nuts. When the set has been lowered to within an inch or so of its final position, remove the fingers and allow the set to drop all the way into the case. The final alignment

of the panel into the case is done by side pressure on the panel if and where necessary. Retighten the four captive screws.

5.03 To Operate from Internal Batteries

1. If the set does not contain batteries, install a group as instructed in paragraph 5.02.

2. Place FUNCTION switch in the DIAL/BAT position.

3. Place the AC-BAT switch (on the rear of the set) in the BAT position.

4. Place the POWER switch to the ON position.

5. Observe the deflection of the BAT TEST meter. This must be within the green arc. If it is not, the batteries should be replaced as instructed in paragraph 6.05.

6. Operate the set as desired and as discussed in the following sections.

NOTE: The BAT TEST meter is to insure that adequate voltage is available to power the equipment. It will be to the user's advantage to develop a habit of using the meter at sufficient intervals to avoid using the instrument with inadequate power (which may give improper measurements). A good practice would be to check the battery condition each time the unit is turned on. When the indication is toward the low end of the green arc (less than 15 volts) the checks should be at more frequent intervals, every hour or two. The voltage is an indication of battery life. Voltages of 17 or 18 volts indicate nearly full life. Voltages of 13 and 14 indicate close to the end of useful life. Such low voltages will still produce satisfactory operation, but the operator should have available a fresh set of batteries since replacement will soon be necessary.

5.04 To Operate from 115V, AC, 60 cps

1. Connect the AC power cord securely into the male receptacle located at the rear of the set.

2. Place the AC-BAT switch in the rear of the set to the AC position.

3. Plug the other end of the power cord into a source of 117V, ±10%, 60 cps power.

4. Turn the POWER switch ON.

NOTE: When the POWER switch is moved to OFF, only the DC output of the AC power supply is turned off; the AC portion of the power supply, including the rectifier, remains connected. Although the AC circuit is fused, it may be desirable to disconnect the AC power cord or turn the AC-BAT switch to BAT when the set is not in use for long periods of time.

5. Place the FUNCTION switch in the DIAL/BAT position and observe that the BAT TEST meter reads within the green arc.

5.05 To Dial a Number

1. Connect the line into the appropriate OUTPUT jack, corresponding to the type connection available.

2. Connect a handset or similar device to the appropriate DIAL jack or clip posts.

3. Place the FUNCTION switch in the DIAL/BAT position.

4. Dial the desired number.

NOTE: It is not necessary to turn the POWER switch ON to dial in this manner. In the DIAL/BAT position of the FUNCTION switch, no connection is made between the circuitry of the set and the output jacks so that even if the set should be on, no signal will appear.

5.06 To Hold a Given Line

1. To establish the connection, dial the desired number as described above.

2. To hold the connection, operate the FUNCTION switch to either 600 HOLD or 900 HOLD. Either position applies a 700-ohm ±10% DC hold circuit which can pass 60 ma DC current.

NOTE: The FUNCTION switch must be rotated to one of the HOLD positions before the dial circuit can be removed and once the FUNCTION switch is rotated, the dial circuit is disconnected from the output jacks.

5.07 To Set a Frequency

1. Set the FREQUENCY VERNIER to the OUT position. This is in the counterclockwise position and is detented.

2. Set the main tuning dial and the FREQ RANGE switch to give the desired frequency.

Note that the FREQ RANGE switch is merely a multiplier. For instance, to send a frequency of 60 cps, the dial should be set to 60 and the FREQ RANGE to X1, while to send a frequency at 6000, the dial would still be set at 60 while the RANGE would be set at X100. Thus, 60 x 100 equals 6000.

5.08 If the frequency desired is not a round number, it will be necessary to interpolate between divisions. For example, if it is desired to produce a frequency of 830, it will be noticed that there is no mark corresponding to 83. However, between 80 and 90 on the dial, there are five subdivisions. Each mark between these two points then corresponds to 2/10. The second mark would be 84, etc. Thus, 83 would be set to be midway between the first and second minor divisions to the right of the 80 mark. The dial would thus be set and the range would be set to X10 to produce a frequency of 830. This will produce a frequency of 830 cps within the ±3% accuracy.

5.09 If the frequency desired is 3285, the dial will be set between 300 and 350. The longer subdivisions between these two cardinal points correspond to increments of 10, thus these represent 310, 320, 330, and 340. The smaller subdivisions are equally spaced within these and therefore represent increments of 5. The smaller subdivision midway between 300 and 350 represents 325. 3285 will therefore occur slightly to the right of this point. It is obviously impossible to estimate the 4th digit and if more exact frequencies are desired, then the use of an external counter must be employed along with the FREQUENCY VERNIER which is described below.

5.10 To Use the FREQUENCY VERNIER

1. With the FREQUENCY VERNIER in the OUT position, set the main tuning adjustment as close as possible to the desired frequency.

2. Turn the FREQUENCY VERNIER clockwise from its detented position to approximately the mid-point of its range. This corresponds closely to the frequency produced in the OUT position.

3. Rotate the FREQUENCY VERNIER to produce the exact frequency desired, as determined by external means. Clockwise rotation will increase the frequency.

5.11 To Set Frequency with an External Counter

1. Connect the appropriate OUTPUT jack to the external counter.

2. Adjust the level to correspond with the sensitivity of the counter.

3. Set FREQUENCY VERNIER approximately midway.

4. With the main tuning adjustment, set the frequency as close as possible to the desired frequency as observed on the counter.

5. Adjust the FREQUENCY VERNIER carefully to give the desired frequency. In this manner, the frequency can normally be adjusted to better than 0.1% of a desired frequency.

5.12 To Set a Given Output Level

1. Set the frequency according to the above instructions.

2. Position the FUNCTION switch to the desired output impedance and connect an appropriate OUTPUT jack to an external power meter. The impedance of this power meter must correspond to the impedance selected by the FUNCTION switch.

3. Set the OUTPUT LEVEL and OUTPUT VERNIER controls to give the desired output level. For power levels between 0 and +10 dbm, the OUTPUT LEVEL control will be in the maximum clockwise position. Rotation of either the OUTPUT LEVEL or OUTPUT VERNIER control clockwise will result in increased output.

CAUTION: Due to the excellent inherent level stability of the set, it is important to eliminate external factors which can affect level stability. These include dirty contacts or plugs, loose connections to cords, and poor contact between clips and terminals. Every effort should be made to assume good connections if the full capability of the oscillator is to be realized.

6.0 MAINTENANCE

6.01 General

Before any extensive trouble shooting is attempted, a few obvious troubles should be checked. These include:

1. Check the supply with the BAT TEST meter.
2. If no reading, check the AC-BAT switch on the rear to be in the proper position.
3. Make sure the FUNCTION switch is not on DIAL/BAT (no output is available).
4. Make sure the circuit is plugged into an OUTPUT jack (and not a DIAL jack).
5. Make sure the FUNCTION switch is in the proper position for both impedance and frequency. (Improper use can produce either a distorted waveform, a severely reduced amplitude, or both.)
6. Be sure the OUTPUT adjustments are high enough for the external device being used.
7. Be sure that external cords have no opens and that the OUTPUT jacks are clean. (This last can usually be checked by using a different OUTPUT jack.)

6.02 To Remove the Set from the Case

Remove the AC power cord from its 117V supply and from the set. The set must be removed from the case for servicing. This may be done by first unfastening the four captive screws on the front panel which hold the panel to the case. They are identified by large slotted heads and are set in from the four smaller screws in each corner by approximately 1". Place the set face down and lift the case from the set. If the unit is to be operated from 117V, reconnect the power cord to the set and a source of power.

CAUTION: When operated from 117V, 60 cps, this voltage appears in the power supply section of the set. This voltage is NOT removed by turning POWER to OFF.

NOTE: It is important to prevent accidental shorts or grounds from hitting the circuitry. Instantaneous damage may result with no warning. It is also important to be aware that the cases of several of the transistors are internally connected to the collector and therefore carry voltages, both signal and DC.

6.03 Locating Circuits to be Tested

All circuits are accessible once the set is removed from its case. It may be necessary to detach the battery tray to gain access to some parts, but this can be accomplished quite readily. A series of pictures in Figs. 3 through 8 show the location of different parts of the set.

Figure 3 is an angle view of the set showing the bottom and right hand side with the battery holder panel removed. All jacks, terminals, electrolytic capacitors, and a board containing the output impedance build-out capacitors are available.

Figure 4 shows the oscillator printed circuit board in a top view of the set. All components are identified on the board by schematic diagram circuit designations. Each adjustment on the board is identified on the photograph.

Figure 5 shows the end view of the set on the right hand side as viewed from the front. The FUNCTION switch, OUTPUT LEVEL switch, and the component board holding components associated with the OUTPUT LEVEL switch can be seen in this view.

Figure 6 shows the same end of the set when the OUTPUT VERNIER control, the OUTPUT LEVEL switch, and the battery holder panel have been removed. The printed circuit board containing the output amplifier, and the DC regulated supply for the oscillator and output amplifier is now accessible for service.

Figure 7 shows the end view of the set on the left hand side as viewed from the front. The printed circuit board contains the capacitors used for setting each timing range. The BAT TEST meter, FREQUENCY VERNIER and FREQ RANGE switch are also accessible.

Figure 8 shows a back view of the set with batteries installed.

6.04 Batteries

In case of any malfunction in the set, the first trouble to be suspected will be the batteries, when battery operation is used. The batteries should first be checked by placing the FUNCTION switch in the BAT/DIAL position, turning the POWER to ON, and observing the deflection of the BAT TEST meter. This must be in the green arc for the batteries to provide sufficient power to the set to meet the specifications. A deflection which barely goes into the green arc indicates that the useful life of the battery is nearing its end and provision should be made for replacement in the near future.

6.05 Battery Replacement

When the batteries have reached a voltage less than that necessary to power the set, which is 12.5 volts, they must be replaced. This should be done in accordance with the procedure outlined in paragraph 5.02. After batteries have been replaced, turn the POWER switch ON and the FUNCTION switch to the DIAL/BAT position and check the deflection of the BAT TEST meter. If there is no deflection, check the AC BAT position on the rear of the set to be sure it is in the BAT position. There is also a possibility that the replacement batteries have been on the shelf a long time and may not be useful.

6.06 Should the replacement of the batteries not result in correct operation, a malfunction within the set is indicated. Normal trouble shooting techniques can be employed to first isolate the trouble and then repair it. The schematic diagrams, Figs. 9 and 10, contain significant DC voltages. Circuit voltages should be tested only if the BAT TEST meter reads in the green arc when the FUNCTION switch is in the DIAL/BAT position. Any sign of deviation from the voltages shown on the diagram can indicate trouble. Listed below are a few symptoms and the possible troubles associated with them. Those voltages associated with 18V will depend on the battery voltage.

6.07 AC Operation

If the set does not function on AC operation, the FUNCTION switch should be turned to DIAL/BAT, the AC-BAT slide switch on the back of the set should be placed in the AC position, and the POWER switch on the panel should be in the ON position. The BAT TEST meter should read in the green arc.

6.08 If the meter does not read at all, check the fuse at the back of the set; a replacement fuse is mounted on the back if the fuse in the AC circuit needs replacement. If the fuse is not blown, check the voltages in the rectifier circuit as shown on the schematic diagram, Fig. 12.

6.09 No Output

1. First check to make sure that the output level is turned high enough to give a reading on an external level meter. Be sure that this meter is plugged into an OUTPUT jack and not into a DIAL jack. The FUNCTION switch should be set to the desired impedance and to a frequency within the frequency range of this impedance. If the above adjustments have been made and no output is obtained, the trouble can be isolated between the amplifier and oscillator by connecting a VTVM or CRO to the oscillator

output directly. Ground for either of these instruments should be made to chassis and the high side connected to the lug on the oscillator board labeled OUT. The level at this point should be approximately 1.5 volts RMS and should be an undistorted sine wave. This is most conveniently checked at 1000 cps to preclude the possibility of any loading being introduced by the capacity of the test equipment.

2. If there is no 1000 cps signal at the OUT lug, the trouble will most likely be a defective Q1 or Q2 and this can be checked with DC voltage measurements. If the level is approximately correct (1.4 to 1.9V RMS), but one half of the cycle is distorted, the trouble is probably due to either Q3 or Q4. Distortion of the negative half cycle is generally due to Q4, while the positive is generally due to Q3.

3. A high level, highly distorted waveform at the oscillator OUT lug, is generally due to Q5 or RT1.

4. Replacement of any of the above transistors or RT1 will generally require a recalibration check of the oscillator. This is described in paragraph 6.10.

5. If the signal at the OUT lug of the oscillator board is normal (but still not normal at the OUTPUT JACKS) then progressive checking of the signal is in order. Place the CRO on the IN lug of the amplifier board. This has a slate colored wire and is located behind the OUTPUT VERNIER assembly and is the uppermost (top of the set) lug. With the OUTPUT LEVEL and OUTPUT VERNIER in their clockwise positions, the level here should be approximately 0.5 volts RMS.

6. If the signal is very low or missing, the trouble will most likely be due to the OUTPUT LEVEL switch or associated components. Continuity or high resistance contacts can be checked with a conventional ohmmeter.

7. If the signal at the IN lug of the amplifier is normal (but still missing or distorted at the OUTPUT), then the waveform at the OUT lug of the amplifier should be checked. This lug is behind the OUTPUT LEVEL switch, is clearly marked, and like the IN lug, is accessible without any dismantling of components. The signal here should be a clean sine wave approximately 1.5 volts RMS (with both the OUTPUT LEVEL and OUTPUT VERNIER clockwise).

8. If the OUT signal is normal but missing from the OUTPUT jacks, the trouble will no doubt be tied in with the switching of the transformer leads in the FUNCTION switch, the impedance matching resistors which are mounted on the transformer, or the OUTPUT jacks. All of these can be checked with an ohmmeter.

9. If the OUT signal is missing, distorted, or low and distorted, the trouble will generally be due to the amplifier Q7, Q8, Q9, and Q10. The significant DC voltages within the amplifier can be measured without dismantling. (Note: The collector voltage of Q8 can more conveniently be measured on its case.)

10. For more extensive trouble shooting, access to the entire amplifier board can be achieved by removing the OUTPUT VERNIER assembly and/or the OUTPUT LEVEL switch. Remove the knobs from the shaft (these have Allen set screws). With a flat, 1/2 inch open end wrench, loosen the mounting nuts. These are accessible between the two front panels. After the nuts are removed, pull out the control from the panel. The leads to both of these controls are long enough to allow them to be swung out of the way and expose the entire amplifier board.

6.10 Setting the REGEN Adjustment

1. If for any reason, (generally a replacement of RT1) the REGEN needs adjustment, the following procedure can be used.

2. Turn the REGEN counterclockwise.

3. Set RANGE to X1.

4. Set FREQ dial to 50.

5. Set FUNCTION to either 600 or 900 and observe the signal at the OUTPUT jacks on a CRO.

6. Normally, under the conditions above, there will be no output. Rotate the REGEN clockwise until an output is observed. This must be done rather slowly as certain circuits associated with this control have a time constant of a few seconds. Certain sets may show an amplitude instability, fluctuating every second or so. Continue the REGEN clockwise and this will cease.

7. Continue the REGEN clockwise until a distortion is observed.

8. Back off the REGEN about 20° from this distortion point going counterclockwise.

9. Switch the RANGE to the other three positions. Oscillations, without clipping, should be produced on all positions. (Note: Going to X1000 there may be a delay of a second or so.) Switching to any other position may produce momentary clipping. These effects are normal.

10. Switch the RANGE back to X1. The amplitude should settle down to a final value within a few seconds.

11. Rotate the dial to 550 and switch through all positions of the RANGE switch. Oscillations, without clipping, should be produced on all ranges.

6.11 Frequency Calibration

1. If, for any reason, the accuracy of the FREQUENCY dial changes due to replacement of either oscillator transistors or tuning elements, the accuracy can be restored by the following procedures.

2. First, determine with the FREQUENCY VERNIER in the OUT position, the percentage errors at three points on the dial, generally 50, 200, and 500 on all four bands; a counter should be used for measuring the frequency of the output signal. If the frequency at 500 on the dial (the high end of the dial) is out of tolerance on all four bands, then an adjustment of R2 (which is located on the oscillator board and shown on Fig. 4) can be made to bring it within the requirements; this adjustment should be made on band 2 (X10). Similarly if the frequency at 50 on the dial (the low end of the dial) is off in the same direction by the same percentage on all four bands, an adjustment of R6 will bring it within tolerance.

3. If the frequency error exists on only one band and is approximately the same percentage over the range of the dial, a padding of the associated range capacitors can be made to bring it within the requirement. To lower the frequency requires the addition of more capacitance and this capacitance should be added equally to both range capacitors involved in the band. The amount of capacitance to be added can be determined by the amount or the percentage that the frequency is off. If the frequency has to be lowered by 2%, then the total capacity must be increased by 2%. If the frequency must be raised, the capacitance must be decreased. This will require

removal of the padding capacitors associated with the band and replacement of these by capacitors having slightly less capacitance. The padding capacitors are mounted on terminals which are in parallel with the main tuning capacitors. The location of the main tuning capacitor for each band is shown on Fig. 7. On band 4 (X1000), trimmers are available to raise or lower the entire band. These trimmers, C4A and C10A, are also shown on Fig. 7. It is important that these trimmers be adjusted to raise or lower the capacity by equal amounts.

4. Condenser C9, 560 KC ADJUST, located on the oscillator board (shown on Fig. 4) is used only for calibrating the upper end of band 4. If it is found that the frequency calibration on band 4 is good up to approximately 400 KC, but poor beyond this frequency, then C9 on the oscillator board can be adjusted to increase or decrease the frequency at the upper end of the dial. C9 has little or no effect at frequencies below 400 KC.

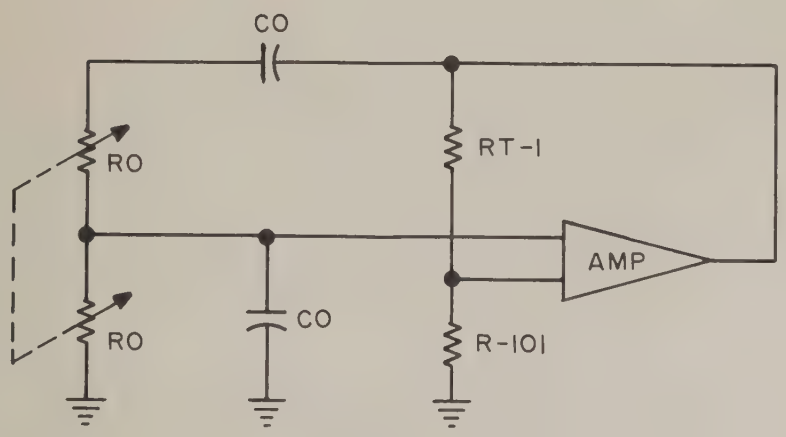

FIG. 2A

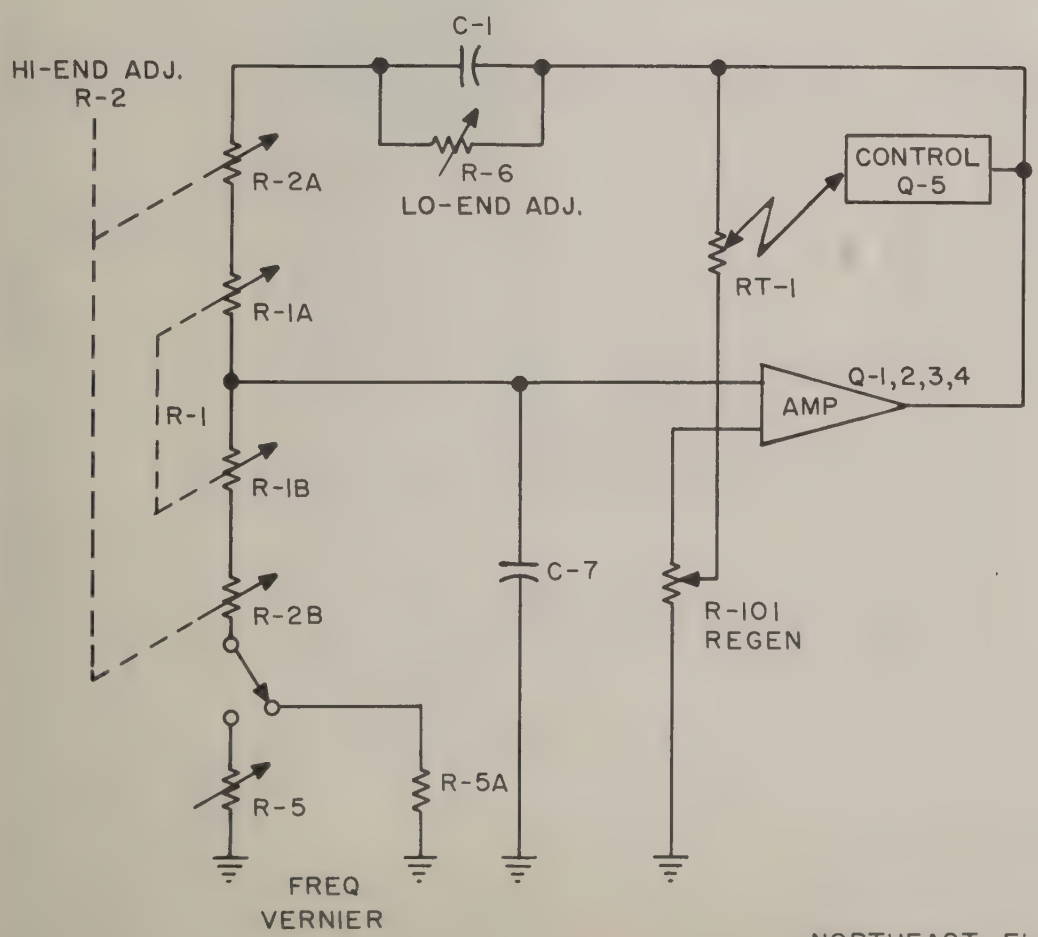

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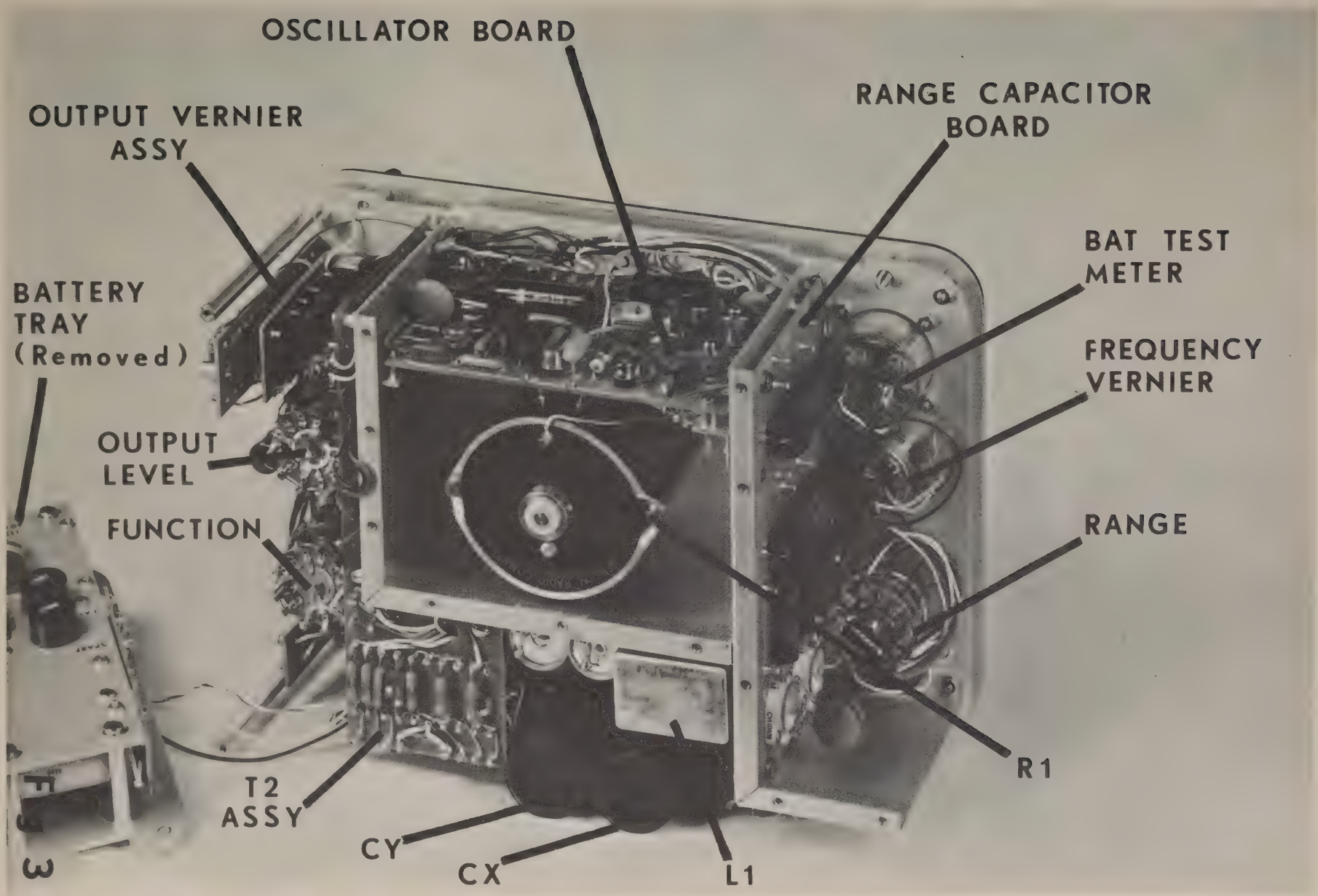
FIG. 2B


OSCILLATOR BOARD
OUTPUT VERNIER ASSY
RANGE CAPACITOR BOARD
BAT TEST METER
BATTERY TRAY (Removed)
FREQUENCY VERNIER
OUTPUT LEVEL
FUNCTION
RANGE
R1
T2 ASSY
CY
CX
L1

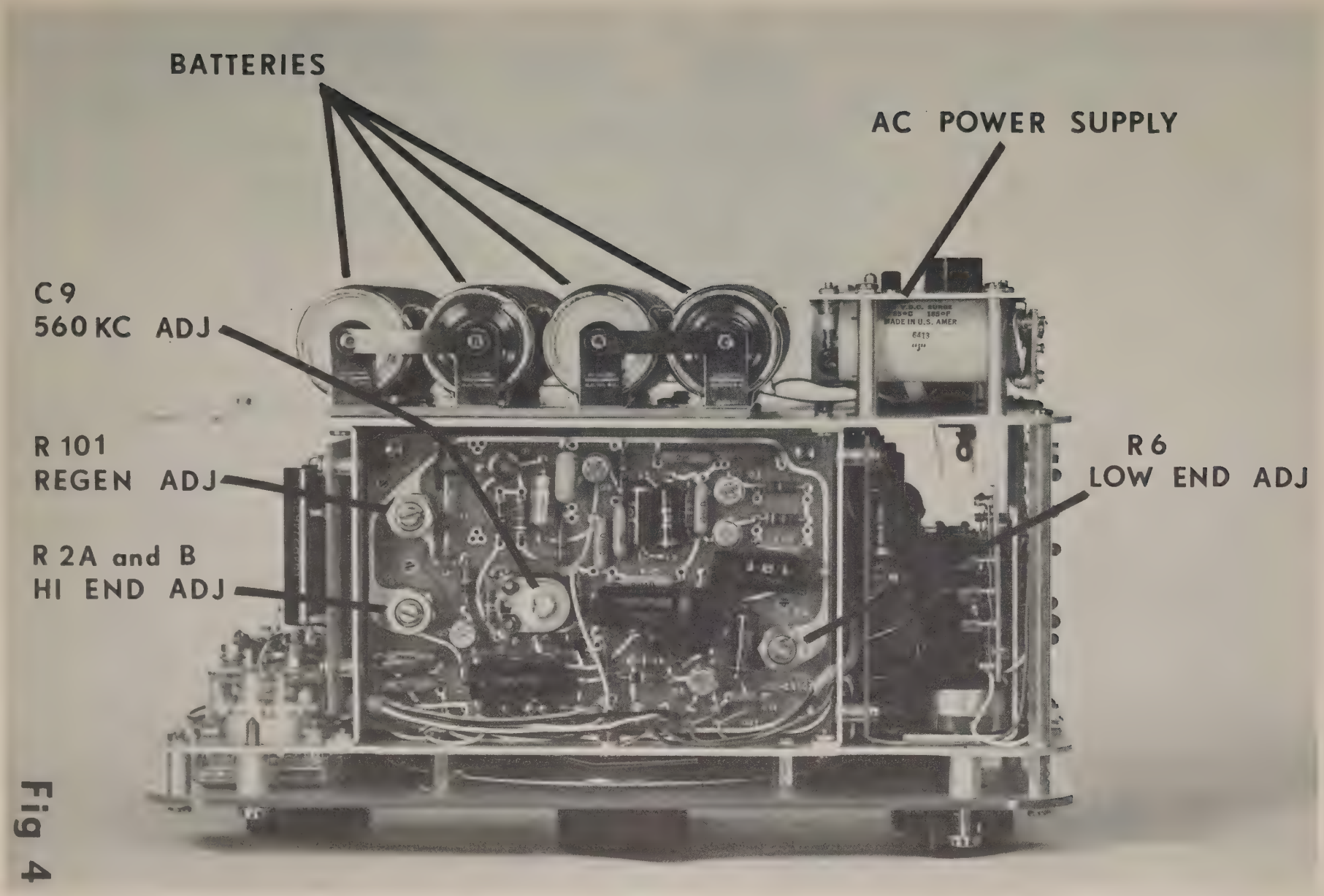

BATTERIES
AC POWER SUPPLY
C9
560 KC ADJ
R 101
REGEN ADJ
R 2A and B
HI END ADJ
R 6
LOW END ADJ

Fig 4

Output Vernier Assembly

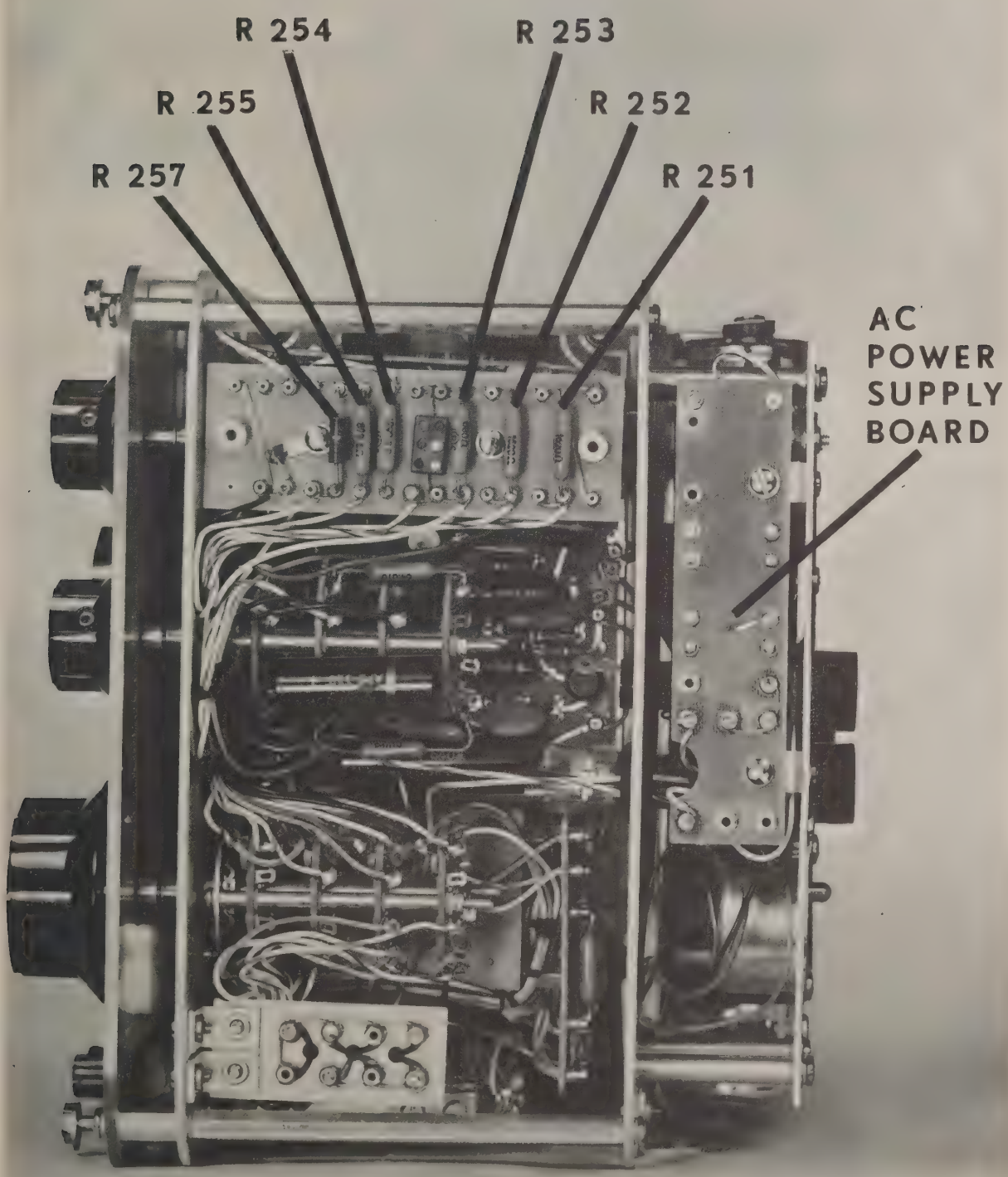
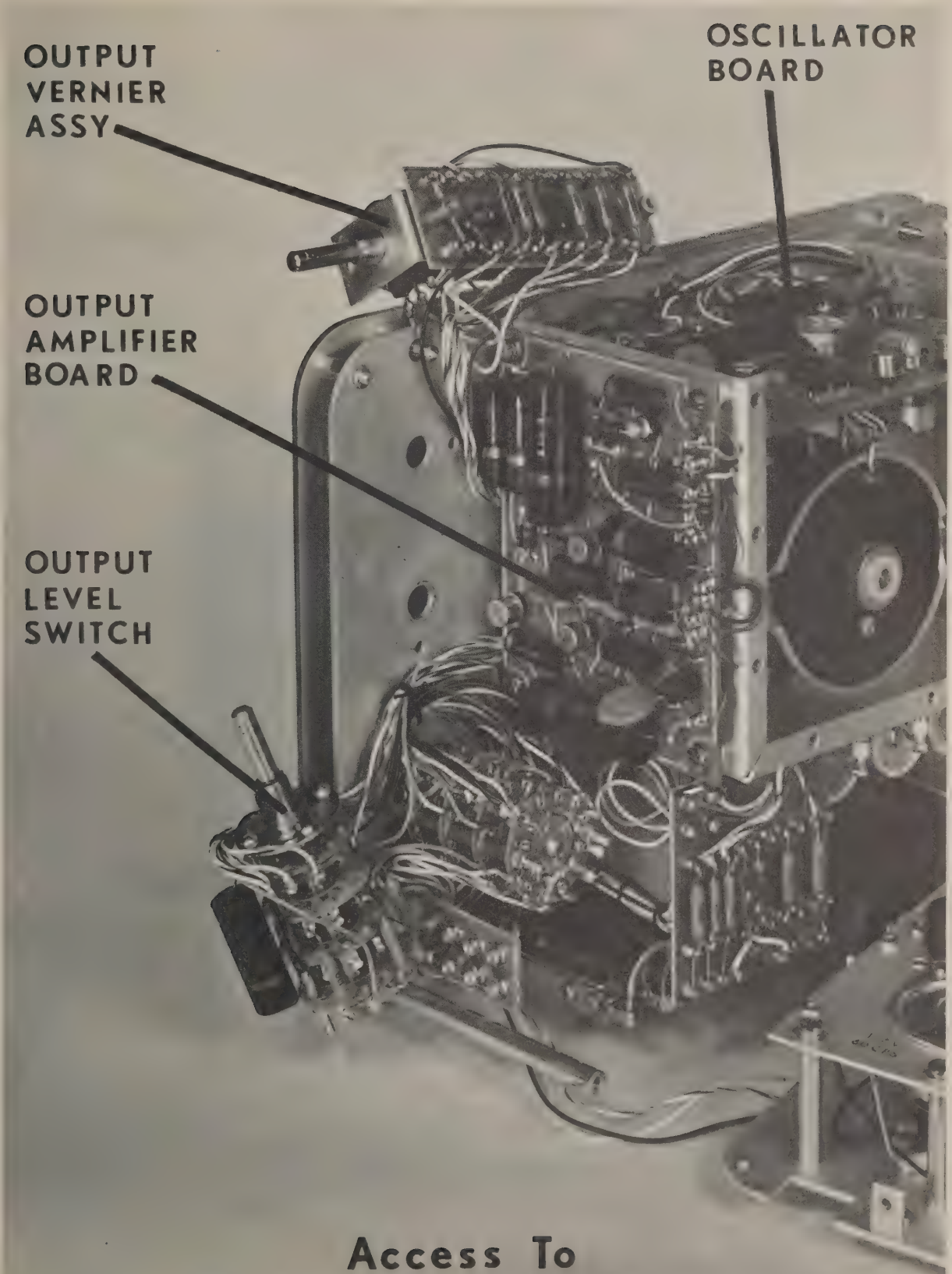
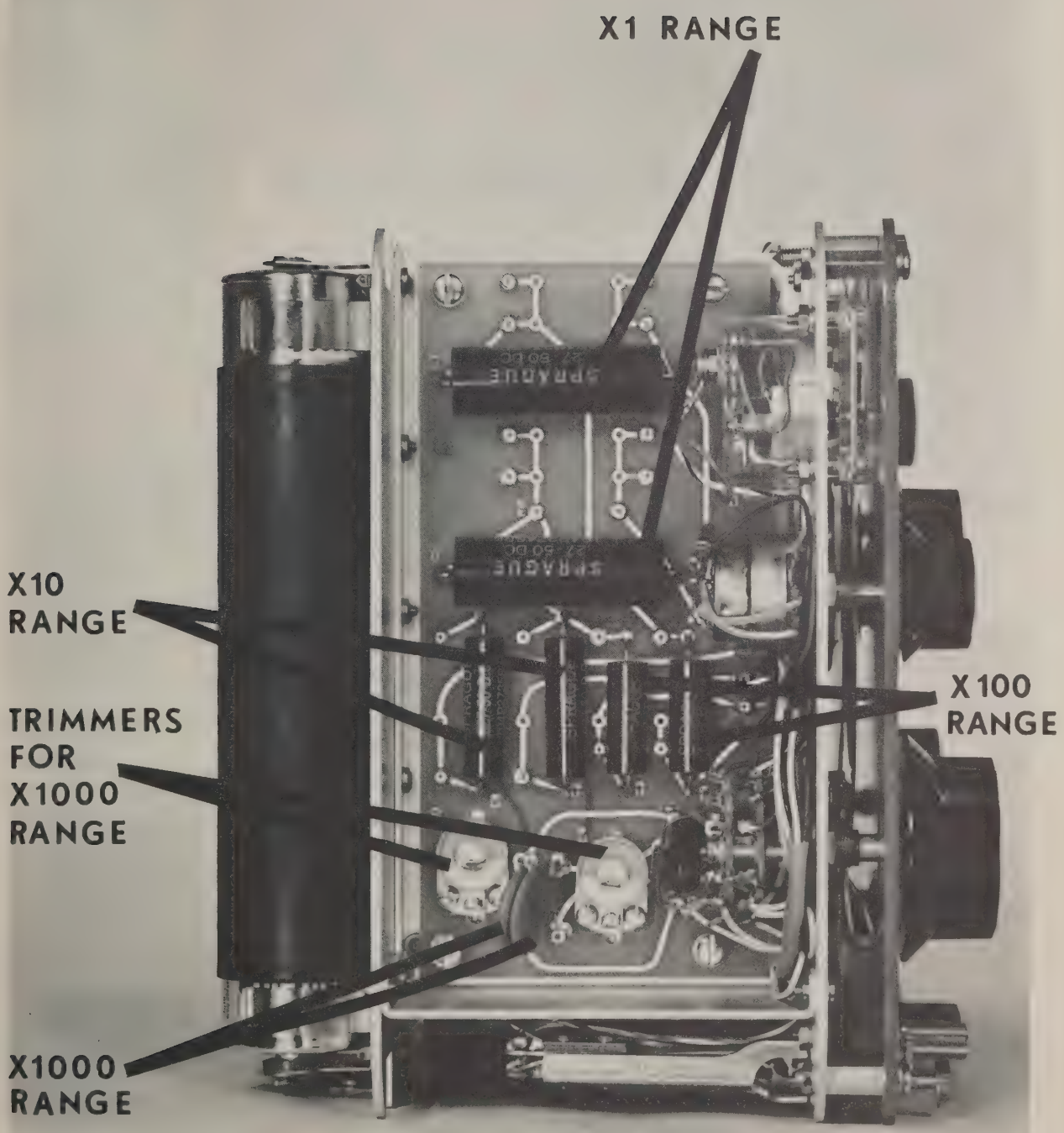


Fig 5



Access To
Output Amplifier Section

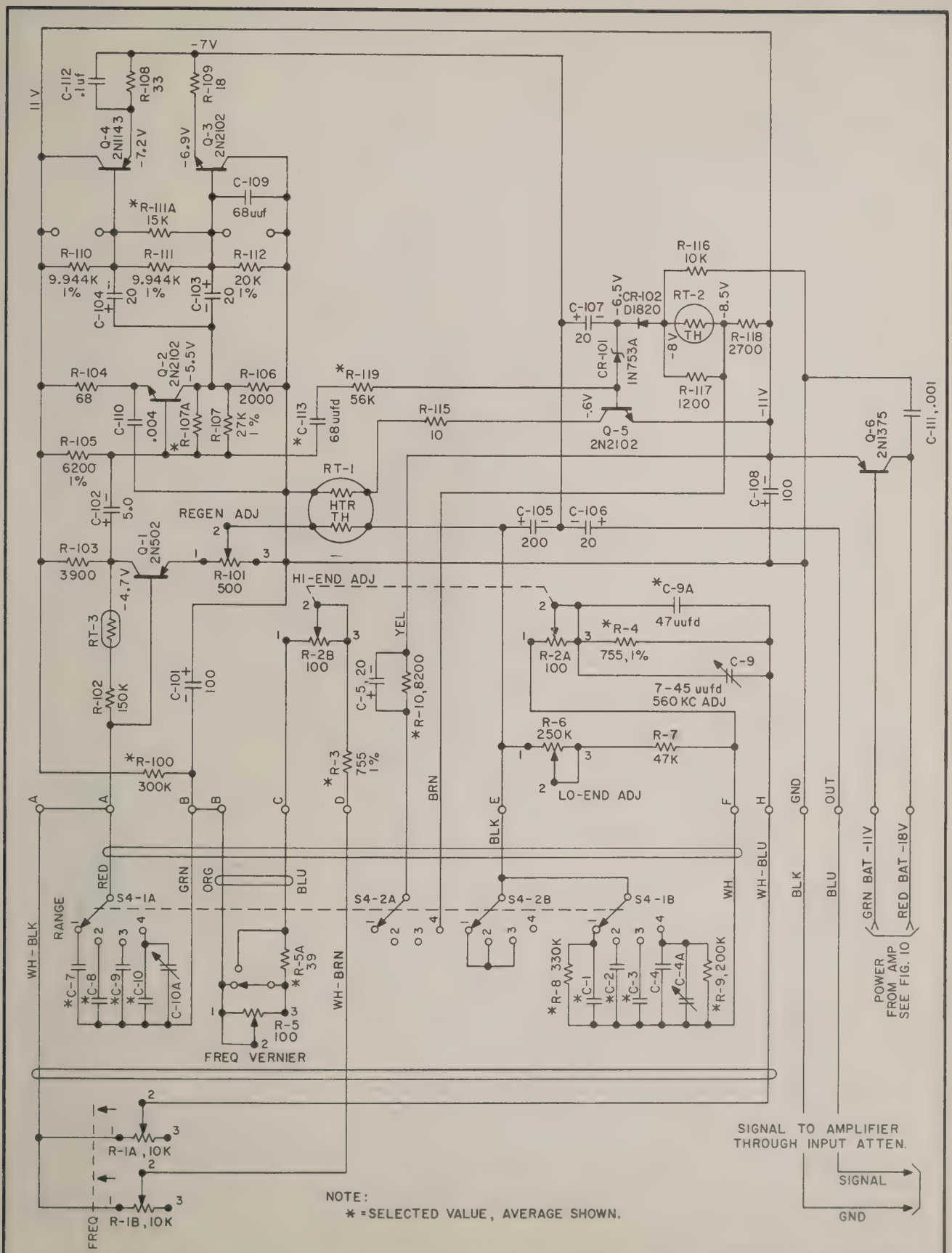
Fig 6



Side View Showing Range Capacitor Board Before Padding

Fig 7

Fig 8



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OSCILLATOR CIRCUIT KS-OSC

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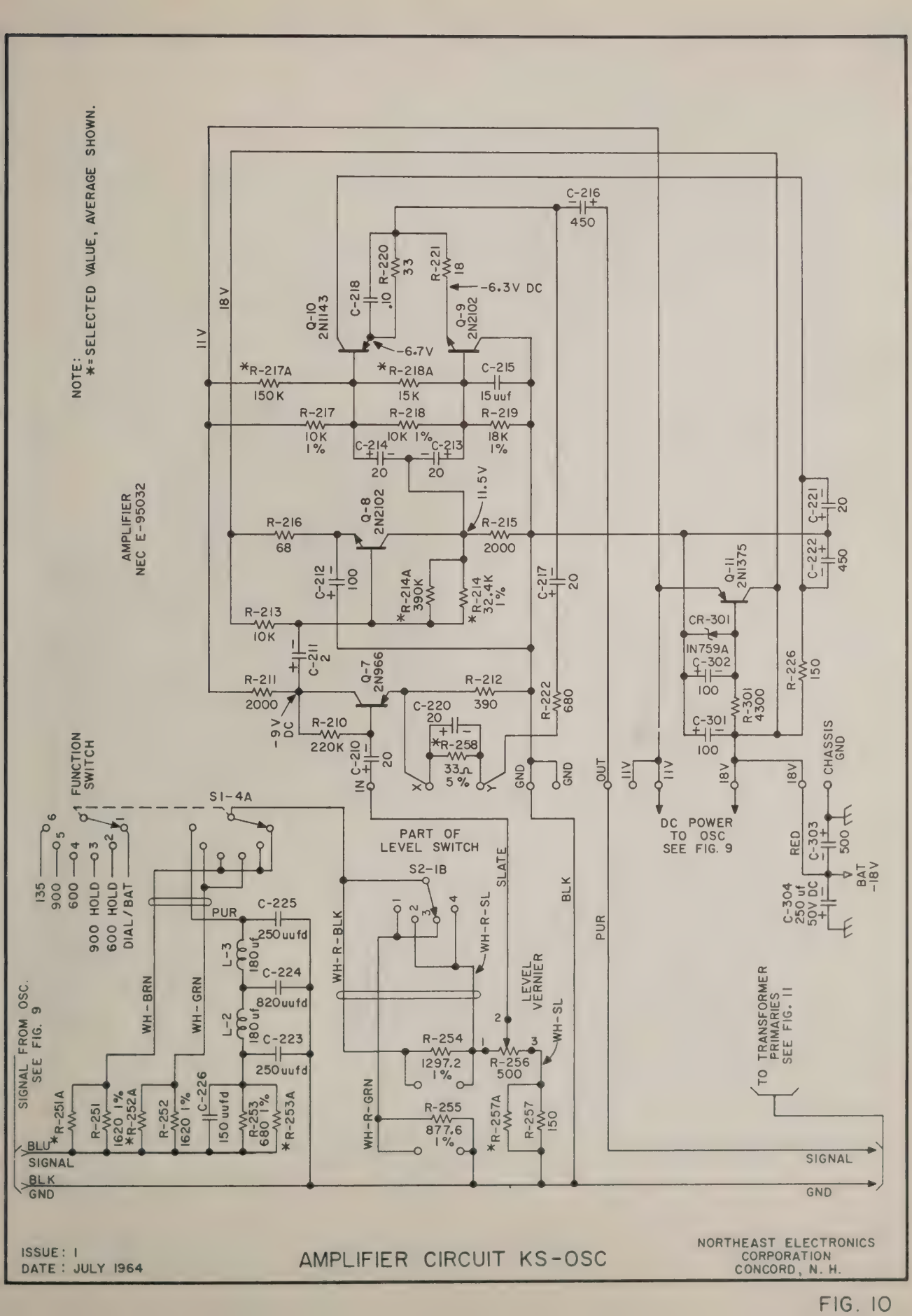
FIG. 9



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AMPLIFIER CIRCUIT KS-OSC

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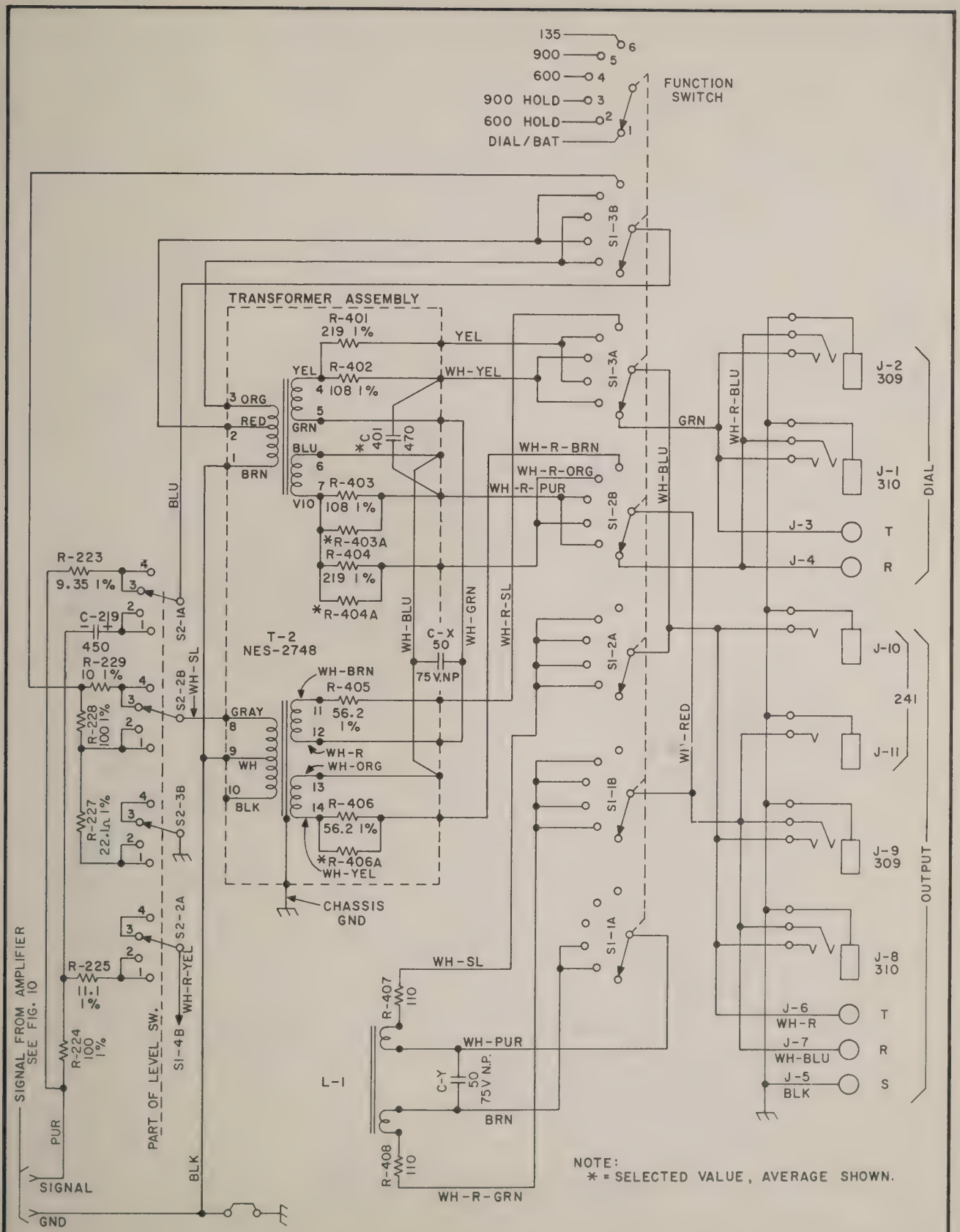
FIG. 10



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OUTPUT CIRCUIT KS-OSC

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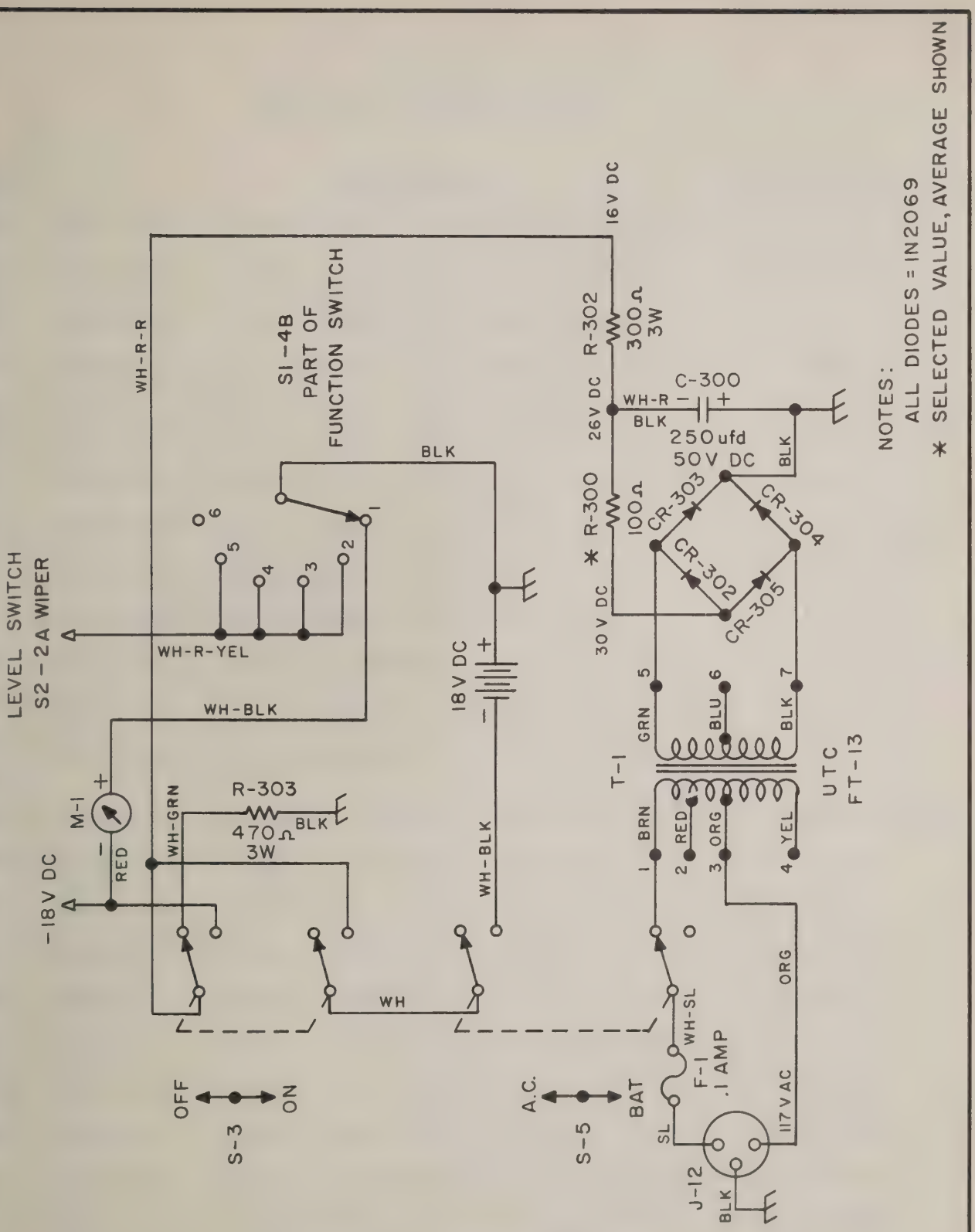
FIG. 11



NOTES:
ALL DIODES = IN2069
* SELECTED VALUE, AVERAGE SHOWN

POWER SUPPLY KS-OSC

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FIG. 12

MODEL KS19353L1 OSCILLATOR
TABLE OF REPLACEABLE PARTS

Circuit Ref		Description	Mfr* & Mfr's Designation
C1	Capacitor:	fixed, paper, .27 mfd, 50 vdc	V, 194P2745R5
C2	Capacitor:	fixed, paper, .027 mfd, 50 vdc	V, 194P2735R5
C3	Capacitor:	fixed, paper, .0027 mfd, 50 vdc	V, 194P2725R5
C4	Capacitor:	fixed, ceramic, 220 mmfd, 1000 vdc, ±5%	V, 10TCC-T22
C4A	Capacitor:	variable, ceramic, 7-45 mmfd, 500 vdc	C, 825BNCV11D450
C5	Capacitor:	fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C7	Capacitor:	fixed, paper, .27 mfd, 50 vdc	V, 194P2745R5
C8	Capacitor:	fixed, paper, .027 mfd, 50 vdc	V, 194P2735R5
C9	Capacitor:	fixed, paper, .0027 mfd, 50 vdc	V, 194P2725R5
C9OSC	Capacitor:	variable, ceramic, 7-45 mmfd, 500 vdc	C, 825BNCV11D450
C9A	Capacitor:	fixed, ceramic, 47 mmfd, 500 vdc, ±5%	V, 10TCC-Q47
C10	Capacitor:	fixed, ceramic, 150 mmfd, 1000 vdc, ±5%	V, 10TCC-T15
C10A	Capacitor:	variable, ceramic, 7-45 mmfd, 500 vdc	C, 825BNCV11D450
C101	Capacitor:	fixed, electrolytic, 100 mfd, 20 vdc	J, APD-095
C102	Capacitor:	fixed, electrolytic, 5 mfd, 15 vdc	V, TE1152
C103	Capacitor:	fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C104	Capacitor:	fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C105	Capacitor:	fixed, electrolytic, 200 mfd, 20 vdc	J, APD-115
C106	Capacitor:	fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C107	Capacitor:	fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C108	Capacitor:	fixed, electrolytic, 100 mfd, 20 vdc	J, APD-095
C109	Capacitor:	fixed, silver mica, 68 mmfd, 500 vdc	A, CM15E680J
C110	Capacitor:	fixed, paper, .004 mfd, 600 vdc	V, 6PS-D40

Circuit Ref	Description	Mfr* & Mfr's Designation
C111	Capacitor: fixed, ceramic, .001 mfd, 500 vdc	V, 5GAB-D10
C112	Capacitor: fixed, ceramic, .1 mfd, 75 vdc	C, DDA-104
C113	Capacitor: fixed, silver mica, 68 mmfd, 500 vdc	A, CM15E680J
C210	Capacitor: fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C211	Capacitor: fixed, electrolytic, 2 mfd, 15 vdc	V, TE1149
C212	Capacitor: fixed, electrolytic, 100 mfd, 20 vdc	J, APD-095
C213	Capacitor: fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C214	Capacitor: fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C215	Capacitor: fixed, silver mica, 15 mmfd, 500 vdc	A, CM15C150J
C216	Capacitor: fixed, electrolytic, 450 mfd, 20 vdc	J, APD-135
C217	Capacitor: fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C218	Capacitor: fixed, ceramic, 0.1 mfd, 75 vdc	C, DDA-104
C219	Capacitor: fixed, electrolytic, 450 mfd, 10 vdc	J, APD-113
C220	Capacitor: fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C221	Capacitor: fixed, electrolytic, 20 mfd, 25 vdc	J, APD-046
C222	Capacitor: fixed, electrolytic, 450 mfd, 20 vdc	J, APD-135
C223	Capacitor: fixed, silver mica, 250 mmfd, 500 vdc	A, CM15E251J
C224	Capacitor: fixed, silver mica, 820 mmfd, 100 vdc	A, CM15E821J
C225	Capacitor: fixed, silver mica, 250 mmfd, 500 vdc	A, CM15E251J
C226	Capacitor: fixed, silver mica, 150 mmfd, 500 vdc	A, CM15E151J
C300	Capacitor: fixed, electrolytic, 250 mfd, 50 vdc	V, TVA-1312
C301	Capacitor: fixed, electrolytic, 100 mfd, 20 vdc	J, APD-095
C302	Capacitor: fixed, electrolytic, 100 mfd, 20 vdc	J, APD-095
C303	Capacitor: fixed, electrolytic, 500 mfd, 25 vdc	V, TVA-1209
C304	Capacitor: fixed, electrolytic, 250 mfd, 50 vdc	V, TVA-1312
C401	Capacitor: fixed, silver mica, 470 mmfd, 300 vdc	A, CM15E471J

TABLE OF REPLACEABLE PARTS

Circuit Ref	Description	Mfr* & Mfr's Designation
CX	Capacitor: fixed, non-polarized, 50 mfd, 75 vdc	V, D27359
CY	Capacitor: fixed, non-polarized, 50 mfd, 75 vdc	V, D27359
R1A& R1B	Potentiometer: variable, wirewound, dual, 10K	I, 975-G2-S20
R2A& R2B	Potentiometer: variable, composition, dual, 100Ω	D, CM32176NP
R3	Resistor: fixed, metal film, 755Ω, 1/2 w, ±1%	K, CEC-TO
R4	Resistor: fixed, metal film, 755Ω, 1/2 w, ±1%	K, CEC-TO
R5	Potentiometer: variable, composition, 100Ω, ±10%	D, CM32179NP
R5A	Resistor: fixed, composition, 39Ω, 1/2 w, ±5%	T, RC20
R6	Potentiometer: variable, composition, 250K, ±10%	D, CM32177NP
R7	Resistor: fixed, composition, 47K, 1/2 w, ±5%	T, RC20
R8	Resistor: fixed, composition, selected value	T, RC20
R9	Resistor: fixed, composition, selected value	T, RC20
R10	Resistor: fixed, composition, 8.2K, 1/2 w, ±5%	T, RC20
R100	Resistor: fixed, composition, 300K, 1/2 w, ±5%	T, RC20
R101	Potentiometer: variable, composition, 500Ω, ±10%	D, CM32178NP
R102	Resistor: fixed, composition, 150K, 1/2 w, ±5%	T, RC20
R103	Resistor: fixed, composition, 3.9K, 1/2 w, ±5%	T, RC20
R104	Resistor: fixed, composition, 68Ω, 1/2 w, ±5%	T, RC20
R105	Resistor: fixed, metal film, 6.2K, 1/2 w, ±1%	K, CEC-TO
R106	Resistor: fixed, composition, 2K, 1/2 w, ±5%	T, RC20
R107	Resistor: fixed, metal film, 27K, 1/2 w, ±1%	K, CEC-TO
R107A	Resistor: fixed, composition, selected value	T, RC20
R108	Resistor: fixed, composition, 33Ω, 1/2 w, ±5%	T, RC20
R109	Resistor: fixed, composition, 18Ω, 1/2 w, ±5%	T, RC20

Circuit Ref	Description	Mfr* & Mfr's Designation
R110	Resistor: fixed, metal film, 9.944K, 1/2 w, ±1%	K, CEC-TO
R111	Resistor: fixed, metal film, 9.944K, 1/2 w, ±1%	K, CEC-TO
R111A	Resistor: fixed, composition, 15K, 1/2 w, ±5%	T, RC20
R112	Resistor: fixed, metal film, 20K, 1/2 w, ±1%	K, CEC-TO
R115	Resistor: fixed, composition, 10Ω, 1/2 w, ±5%	T, RC20
R116	Resistor: fixed, composition, 10K, 1/2 w, ±5%	T, RC20
R117	Resistor: fixed, composition, 1.2K, 1/2 w, ±5%	T, RC20
R118	Resistor: fixed, composition, 2.7K, 1/2 w, ±5%	T, RC20
R119	Resistor: fixed, composition, 56K, 1/2 w, ±10%	T, RC20
R210	Resistor: fixed, composition, 220K, 1/2 w, ±5%	T, RC20
R211	Resistor: fixed, composition, 2K, 1/2 w, ±5%	T, RC20
R212	Resistor: fixed, composition, 390Ω, 1/2 w, ±5%	T, RC20
R213	Resistor: fixed, composition, 10K, 1/2 w, ±5%	T, RC20
R214	Resistor: fixed, metal film, 32.4K, 1/2 w, ±1%	K, CEC-TO
R214A	Resistor: fixed, composition, 390K, 1/2 w, ±5%	T, RC20
R215	Resistor: fixed, composition, 2K, 1/2 w, ±5%	T, RC20
R216	Resistor: fixed, composition, 68Ω, 1/2 w, ±5%	T, RC20
R217	Resistor: fixed, metal film, 10K, 1/2 w, ±1%	K, CEC-TO
R217A	Resistor: fixed, composition, 150K, 1/2 w, ±5%	T, RC20
R218	Resistor: fixed, metal film, 10K, 1/2 w, ±1%	K, CEC-TO
R218A	Resistor: fixed, composition, 15K, 1/2 w, ±5%	T, RC20
R219	Resistor: fixed, metal film, 18K, 1/2 w, ±1%	K, CEC-TO
R220	Resistor: fixed, composition, 33Ω, 1/2 w, ±5%	T, RC20
R221	Resistor: fixed, composition, 18Ω, 1/2 w, ±5%	T, RC20
R222	Resistor: fixed, composition, 680Ω, 1/2 w, ±5%	T, RC20

Circuit Ref	Description	Mfr* & Mfr's Designation
R223	Resistor: fixed, metal film, 9.35Ω, 1/2 w, ±1%	D, RN70B
R224	Resistor: fixed, metal film, 100Ω, 1/2 w, ±1%	K, CEC-TO
R225	Resistor: fixed, metal film, 11.1Ω, 1/2 w, ±1%	K, CEC-TO
R226	Resistor: fixed, composition, 150Ω, 1/2 w, ±10%	T, RC20
R227	Resistor: fixed, metal film, 22.1Ω, 1/2 w, ±1%	K, CEC-TO
R228	Resistor: fixed, metal film, 100Ω, 1/2 w, ±1%	K, CEC-TO
R229	Resistor: fixed, metal film, 10Ω, 1/2 w, ±1%	K, CEC-TO
R251	Resistor: fixed, metal film, 1.620K, 1/2 w, ±1%	K, CEC-TO
R251A	Resistor: fixed, composition, selected value	T, RC20
R252	Resistor: fixed, metal film, 1.620K, 1/2 w, ±1%	K, CEC-TO
R252A	Resistor: fixed, composition, selected value	T, RC20
R253	Resistor: fixed, metal film, 680Ω, 1/2 w, ±1%	K, CEC-TO
R253A	Resistor: fixed, composition, selected value	T, RC20
R254	Resistor: fixed, metal film, 1297.2Ω, 1/2 w, ±1%	K, CEC-TO
R255	Resistor: fixed, metal film, 877.6Ω, 1/2 w, ±1%	K, CEC-TO
R256	Potentiometer: variable, composition, 500Ω, ±10%	D, CM32175NP
R257	Resistor: fixed, composition, 150Ω, 1/2 w, ±10%	T, RC20
R257A	Resistor: fixed, composition, selected value	T, RC20
R258	Resistor: fixed, composition, 33Ω, 1/2 w, ±5%	T, RC20
R300	Resistor: fixed, composition, 100Ω, 1/2 w, ±5%	T, RC20
R301	Resistor: fixed, composition, 4.3K, 1/2 w, ±5%	T, RC20
R302	Resistor: fixed, wirewound, 300Ω, 3 w, ±5%	V, 450E3015
R303	Resistor: fixed, wirewound, 470Ω, 3 w, ±5%	V, 450E4715
R401	Resistor: fixed, metal film, 219Ω, 1/2 w, ±1%	K, CEC-TO

Circuit Ref	Description	Mfr* & Mfr's Designation
R402	Resistor: fixed, metal film, 108Ω, 1/2 w, ±1%	K, CEC-TO
R403	Resistor: fixed, metal film, 108Ω, 1/2 w, ±1%	K, CEC-TO
R403A	Resistor: fixed, composition, selected value	T, RC20
R404	Resistor: fixed, metal film, 219Ω, 1/2 w, ±1%	K, CEC-TO
R404A	Resistor: fixed, composition, selected value	T, RC20
R405	Resistor: fixed, metal film, 56.2Ω, 1/2 w, ±1%	K, CEC-TO
R406	Resistor: fixed, metal film, 56.2Ω, 1/2 w, ±1%	K, CEC-TO
R406A	Resistor: fixed, composition, selected value	T, RC20
R407	Resistor: fixed, composition, 110Ω, 1/2 w, ±5%	T, RC20
R408	Resistor: fixed, composition, 110Ω, 1/2 w, ±5%	T, RC20
J1	Jack: (DIAL) 310 type	W, 5J-1358CMT
J2	Jack: (DIAL) 309 type	W, 5J-1359MT
J3	Clip Post: (T) N. P.	O, A10562
J4	Clip Post: (R) N. P.	O, A10562
J5	Binding Post: (S) brass N. P. with 938-F spacer	I, 938-A
J6	Binding Post: (T) with 938-F spacer	I, 938-C
J7	Binding Post: (R) with 938-F spacer	I, 938-C
J8	Jack: (OUTPUT) 310 type	W, 5J-1358CMT
J9	Jack: (OUTPUT) 309 type	W, 5J-1359MT
J10	Jack: (OUTPUT) 241 type	W, 5J-1194
J11	Jack: (OUTPUT) 241 type	W, 5J-1194
S1	Switch: rotary, 8 pole, 6 position (FUNCTION)	S, 241362F4
S2	Switch: rotary, 8 pole, 4 position (OUTPUT LEVEL)	S, 241363F4

TABLE OF REPLACEABLE PARTS

Circuit Ref	Description	Mfr* & Mfr's Designation
S3	Switch: toggle, DPDT, (POWER)	E, 8363K7
S4	Switch: rotary, 4 position, 4 pole (FREQ RANGE)	NEC, A10792
S5	Switch: slide, DPDT (AC BAT)	S, 3231-301
T1	Transformer: AC power	AA, FT-13
T2	Transformer: output	R,2748
L1	Inductor:	B,2740J
L2	Inductor: 180 microhenries	F, 153788
L3	Inductor: 180 microhenries	F, 153788
Q1	Transistor	V, 2N502
Q2	Transistor	U, 2N2102
Q3	Transistor	U, 2N2102
Q4	Transistor	P, 2N1143
Q5	Transistor	U, 2N2102
Q6	Transistor	Y, 2N1375
Q7	Transistor	X, 2N966
Q8	Transistor	U, 2N2102
Q9	Transistor	U, 2N2102
Q10	Transistor	P, 2N1143
Q11	Transistor	Y, 2N1375
	Knobs for switches S1 and S4 and R1	L, 649-3L-BB
	Knobs for switch S2 and R5, R256	L, 648-3L-BB
M1	Meter: special	NEC, Model 5
CR101	Zener Diode:	Z, 1N753A

Circuit Ref	Description	Mfr* & Mfr's Designation
CR102	Diode	X, D1820
CR301	Zener Diode	Z, 1N759A
CR302	Diode	X, 1N2069
CR303	Diode	X, 1N2069
CR304	Diode	X, 1N2069
CR305	Diode	X, 1N2069
XF1	Fuseholder	M, 341001
F1	Fuse: 0.1 amp	M, 3AG-SLO-BLO
RT1	Thermistor	H, B8.320.15P/3K3
RT2	Thermistor	G, KA3IL1
RT3	Thermistor	BB, VECO 43R1

* See "List of Manufacturer's Code Letters for Replaceable Parts Table" on Page 9.

LIST OF MANUFACTURERS CODE LETTERS FOR REPLACEABLE PARTS TABLE

A	Arco Electronics, Inc.
B	Automatic Electric Company
C	Centralab
D	Clarostat Manufacturing Company
E	Cutler-Hammer, Inc.
F	Delevan
G	Fenwal Electronics, Inc.
H	Feroxcube
I	General Radio Company
J	International Electrical Industries
K	International Resistance Company
L	Kurz-Kasch, Inc.
M	Littlefuse
NEC	Northeast Electronics Corporation
O	Lynn Screw
P	Motorola Semi-Conductors Products, Inc.
R	Newton Engineering Service, Inc.
S	Oak Manufacturing Company
T	Ohmite
U	Radio Corporation of America
V	Sprague Electric Company
W	Switchcraft, Inc.
X	Sylvania Electric Company
Y	Texas Instruments, Inc.
Z	Transitron Electronic Corporation
AA	United Transformer Company
BB	Victory Engineering Company